PATENT SPECIFICATION

DRAWINGS ATTACHED

859,097

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COMPLETE SPECIFICATION

Apparatus for Effecting an Exchange of Heat and/or Material between a Gas or Vapour and a Liquid

I, CLAES WILHELM PILO, a citizen of the Kingdom of Sweden, of 2, Lovisagatan, Stockholm, Sweden, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an apparatus for effecting the exchange of heat and/or material between a gas or vapour and a liquid, and of the kind hereinafter referred to as "the kind specified", which comprises a rotatable annular body having a multiplicity of surfaces over which films of the liquid flow from inside outwardly under a centrifugal effect whilst the gas or the vapour passes from the exterior inwardly in a turbulent flow through the spaces between the surfaces and thus contacts the liquid films.

Apparatus of the kind specified has, in the past, taken many and various forms. For example the said rotatable annular body was provided with irregularly-disposed surfaces, and the annular space was filled with packings, as known for example in the chemical industry. Moreover, it has previously been proposed to form the said surfaces, over which films of the liquid flow from flat or curved sheet metal, the space between adjacent surfaces in every instance increasing outwardly from the inside, or large intermediate spaces being provided between separate packs of parallel plates for the gas-liquid contact.

It has now ben found that to obtain an optimum exchange between the gas or vapour and the liquid in apparatus of the kind specified, it is best that substantially the same conditions shall prevail from the beginning to the end of the contact zones, one particularly important effect of this being that the flow velocity of the gas or vapour remains constant, or at least does not decrease, as the gas or vapour moves inwards. To this end it is required that the rotary annular body shall only incorporate gas and liquid passageways which are such as to ensure a substantially constant gas velocity over their entire lengths.

This technical aim is met, in accordance with this invention, by arranging that the plates forming the surfaces over which films of the liquid flow are mainly perpendicular to the plane of rotation of the said annular body and that the plates which between themselves form flow passages, are curved in such a manner that the line of intersection between a plane parallel to said plane of rotation any any one such plate is a part of a spiral and that the said plates are arranged such that the cross-sectional area at right angles to the flow path defined between any two of such plates is substantially constant throughout the length of such flow path.

It has also been found that when the plates in the rotatable body are shaped and arranged in accordance with the present invention, a total surface area is made available for the contact between the gas or vapour and liquid film which is about 1.5 times larger than the maximum contact area that it has been possible to devise within a rotatable annular body of the same size having any other formation of the plates and with a ratio of the inner diameter to the outer diameter of the annular body of about 1:2.

Further features of the invention are disclosed in the accompanying drawings which diagrammatically illustrate an embodiment thereof, and in the following description relating thereto.

Figure 1 is a vertical section through the rotating contact apparatus in this embodiment.

Figure 2 is a horizontal section through this apparatus, and

Figure 3 is a perspective view of the rotating annular body.

The apparatus illustrated comprises a gas-tight fixed housing 10. Gas or vapour is fed into this housing through the connection pipe or pipes 11 at the outer margin of the housing, preferably, as shown, in tangential fashion. The gas or vapour passes inwards of the housing under an artificially-induced pressure gradient and leaves the housing through the connection 12. The liquid with which the gas or vapour is to be contacted passes through a feed conduit 13 to a distributor spray 14 which turns at a prescribed speed and sprays the liquid in the form of one or more cones of liquid over the inner surface of a rotating annular body 15. The liquid finally runs out of the housing through a drain opening 16.

The annular body 15 is mounted on a spindle 17 and is rotated, for example at 200 revolutions per minute, by a drive mechanism which has not been shown. The speed of rotation of the distributor spray 14 can be the same as, or different from, that of the body 15, but normally the direction of rotation of these two rotary bodies will be the same.

To prevent the gas or vapour flowing direct from a pipe 11 to the outlet 12 without traversing the body 15, packing means 18, which are impregnated with liquid and have their optimum sealing effect when the annular body 15 is rotating, are provided between the housing 10 and the body 15. Usually the liquid which is to be brought into contact with the gas or vapour in this apparatus will serve as the sealing liquid, and the distributor spray 14 in such case is arranged so that an adequate quantity of liquid for sealing purposes is supplied continuously to the packing means 18.

The distribution of the liquid which in the illustrated apparatus is effected by means of rotary sprays 14, can be produced in other ways. Thus, for example, it is possible to provide rotary, upright, radially-extending plates to which the liquid is directed in the vicinity of the axis of rotation thereof. This liquid will then be thrown out centrifugally into the rotating annular body 15.

The annular rotating body 15 consists of upper and lower plates 19 and 20 respectively, which are parallel to the plane of rotation and spaced by an amount determined by the height of curved plates 21 disposed perpendicularly between them. The complete annular chamber formed between plates 19 and 20 is uniformly filled with the curved plates 21, which are spaced to provide a set of flow paths for the gas or vapour between its inlet into the housing and the liquid sprays 14.

The annular body may be bounded internally and externally in any approved manner known *per se*, for example, by perforated plates, by wire mesh or the like. It is also possible to dispense with a bounding surface at the inner and/or the outer boundary of the annular body, that is to say to leave the entrance and/or the exit from the flow paths between the adjacent plates unobstructed.

The curvature of the plates 21 is so chosen that the lines at which they intersect the upper and lower plates 19 and 20 represent portions of spirals and the said plates are arranged such that the cross-sectional area at right angles to the flow path defined between any two of such plates is substantially constant throughout the length of such flow path, so that the gas or vapour entering from the exterior can flow inwardly through these flow paths with a substantially constant velocity. As a result there is a uniform amount of turbulence at all parts and thus a very effective exchange effect. In the event that inner ends of the plates 21 have tangents at right angles to the inner boundary of the rotating body, the angle γ between the radius r_o to the inner end of a plate 21 and the radius of length r between the rotational centre and any point on such plate is given by the equation:

$$\gamma=\sqrt{\left(\frac{r}{r_o}\right)^{2}-1}-\arccos\left(\frac{r_o}{r}\right)$$

There is no special consideration as regards the width of the annular body 15. It is found, in fact, that the wider the annular body, that is, the larger the ratio of the outer diameter to the inner diameter, the smaller is the angle between the tangent to the outer end of a plate 21 and the outer periphery of the annular body, and hence the smaller the component of the centrifugal force causing the movement of the liquid outwardly over the plate 21. At the same time, however, the centrifugal force acting on the liquid at any point on a plate 21 increases in proportion to the distance of the point from the axis of rotation. Thus, with the plates 21 curved in the manner set forth, the reduction in the centrifugal force component acting to cause flow of the liquid over a plate is directly compensated by the increase in the radial centrifugal force as the liquid flows outwards, that is to say the liquid moves over the plate substantially under the influence of a constant force. It has been possible to determine however, that in view of the special flow conditions which prevail in the region of the outer boundary of the rotating body on account of the considerable gas velocity, the width of the annular body should normally be so selected that the angle between the outer boundary thereof and the tangent to the outer end of a plate 21 is not less than about 25—30°.

The spacing between the plates 21 within the annular body can be determined in any desired appropriate fashion. Abutments in which the individual plates 21 are mounted

may be provided at the inner and outer boundaries of the annular body.

It is also possible, as shown by Figure 2, to provide the plates 21 with nib-form projections 22. Owing to the spiral curvature, a nib on one plate does not register with the corresponding recess of the adjaecnt plate, so that the nibs can be applied to all the plates by a common tool. If desired, the plates may be mounted by first fixing a standard plate 23, which for example may be of substantial thickness and be curved in accordance with the exact required dimensions, inside the annular body and then pressing the other plates, which may be of very thin material, on the plate 23 which serves as a template. When the nibs 22 are formed and aplied to the plates, which may for example be initially plane, all the plates may be brought to the required curvature by light mutual pressure between them, thus allowing a very simple assembly.

Normally the plates 21 will be made of a material having a surface which is wetted by the liquid to be treated, since this will ensure that there is a very uniform spreading of the liquid over the surfaces of the plates. It may perhaps be of advantage to provide some irregularities in the surface of the plate in order to prevent the formation of streamlines on this surface. Under some circumstances it may also be of advantage to provide the plates with holes as shown at 24 to produce a very uniform distribution of liquid over all the plates, particularly when the type of liquid supply to the plates does not ensure that there will be a temporarily uniform coating of all the plates with liquid.

WHAT I CLAIM IS:—

1. Apparatus of the kind specified, wherein the plates forming the surfaces over which films of the liquid flow are mainly perpendicular to the plane of rotation of said annular body and that the plates which between themselves form flow passages, are curved in such manner that the line of intersection between a plane parallel to said plane of rotation and any one such plate is a part of a spiral and that the said plates are arranged such that the cross-sectional area at right angles to the flow path defined between any two of such plates is substantially constant throughout the length of such flow path.

2. Apparatus according to Claim 1, in which a tangential plane to the curved plates through the inner periphery of the rotatable annular body is radial.

3. Apparatus according to Claims 1 or 2, in which the angle between a tangent to the outer periphery of the annular body and a tangent to the outer end of a curved plate is at about 25—30°.

4. Apparatus according to any of Claims 1 to 3, in which the ratio of the outer radius to the inner radius of the annular body is aproximately two to one.

5. Apparatus according to any of Claims 1 to 4, in which the plates are furnished with projections which determine the distance between adjacent plates.

6. Apparatus according to any of Claims 1 to 5, in which the plates are perforated.

7. Apparatus for effecting heat and/or material exchange between a gas or vapour and a liquid, substantially as herein described with reference to the acompanying drawings.

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1 SHEET

FIG. 1.

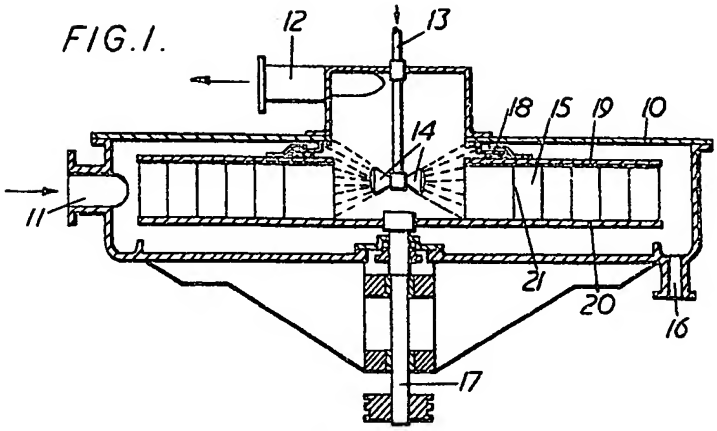

FIG. 2.

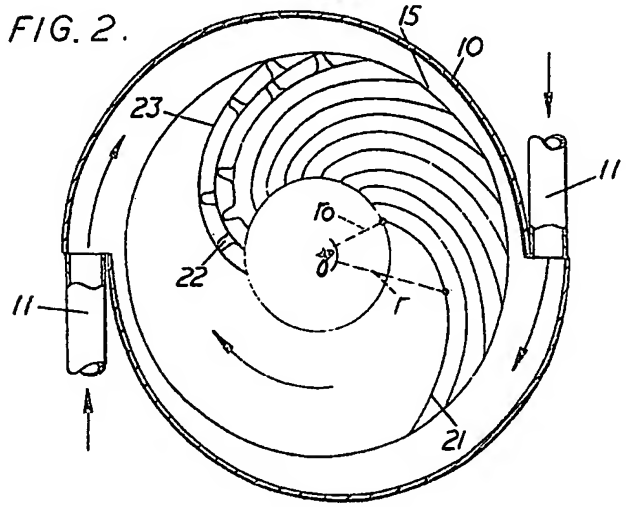

FIG. 3.